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(54) **TOROIDAL CONTINUOUSLY VARIABLE TRANSMISSION**

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(52) **U.S. Cl.**
CPC *F16H 15/38* (2013.01)

(58) **Field of Classification Search**
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See application file for complete search history.

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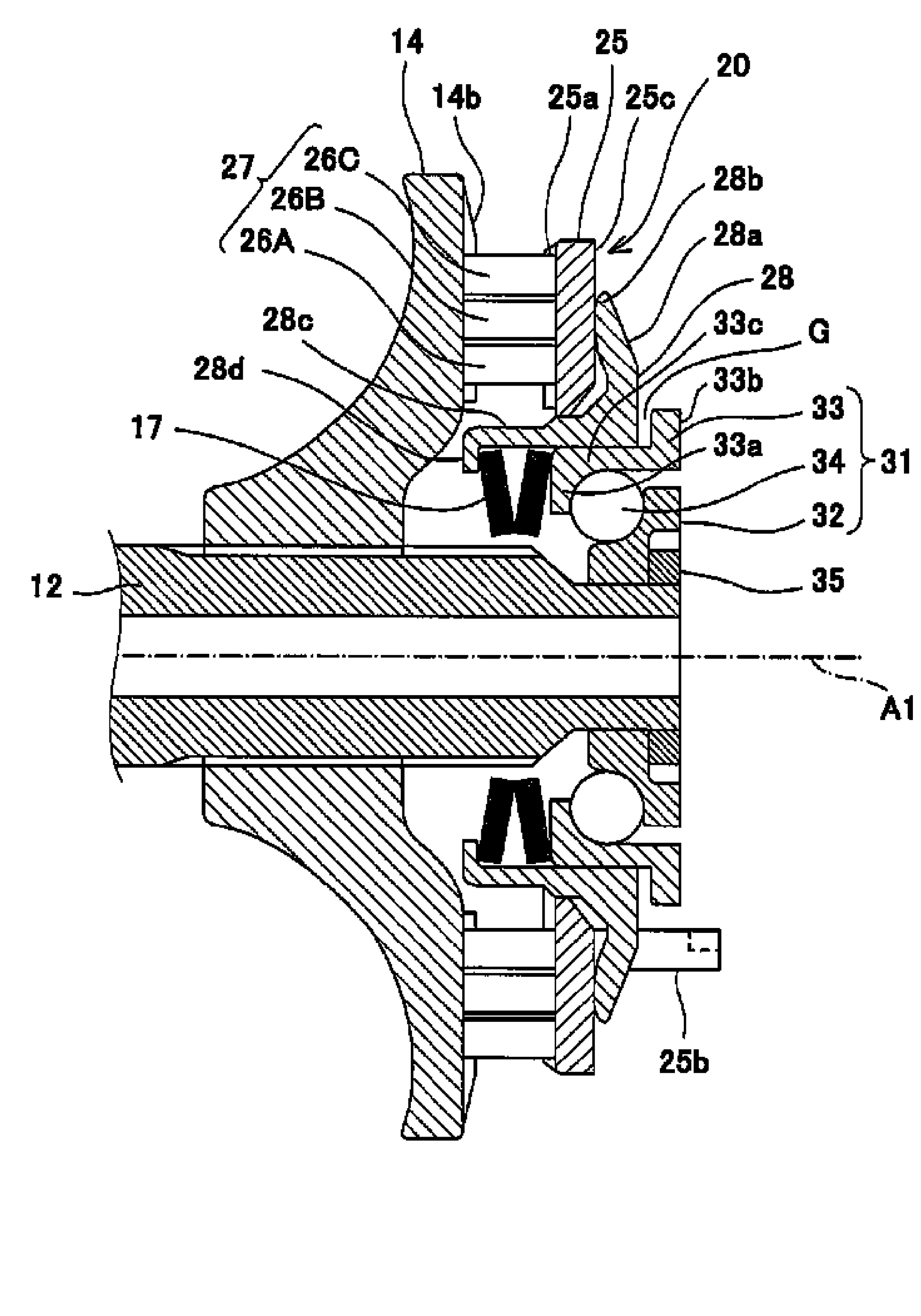
(57) **ABSTRACT**

A toroidal continuously variable transmission includes a first disc and a second disc disposed so that the first disc and the second disc are rotatable around a common rotational axis line, the first disc and the second disc facing each other; a power roller which is tiltably disposed between the first disc and the second disc; a pressing device of a loading cam type, the pressing device including a cam plate which is rotatable around the rotational axis line, and a roller unit including at least one roller sandwiched between a cam surface of the second disc and a cam surface of the cam plate; and a cam plate support supporting a back surface of the cam plate, the back surface being opposite to the cam surface of the cam plate, at a radial position conforming to a radial position of at least a portion of the roller unit.

13 Claims, 7 Drawing Sheets



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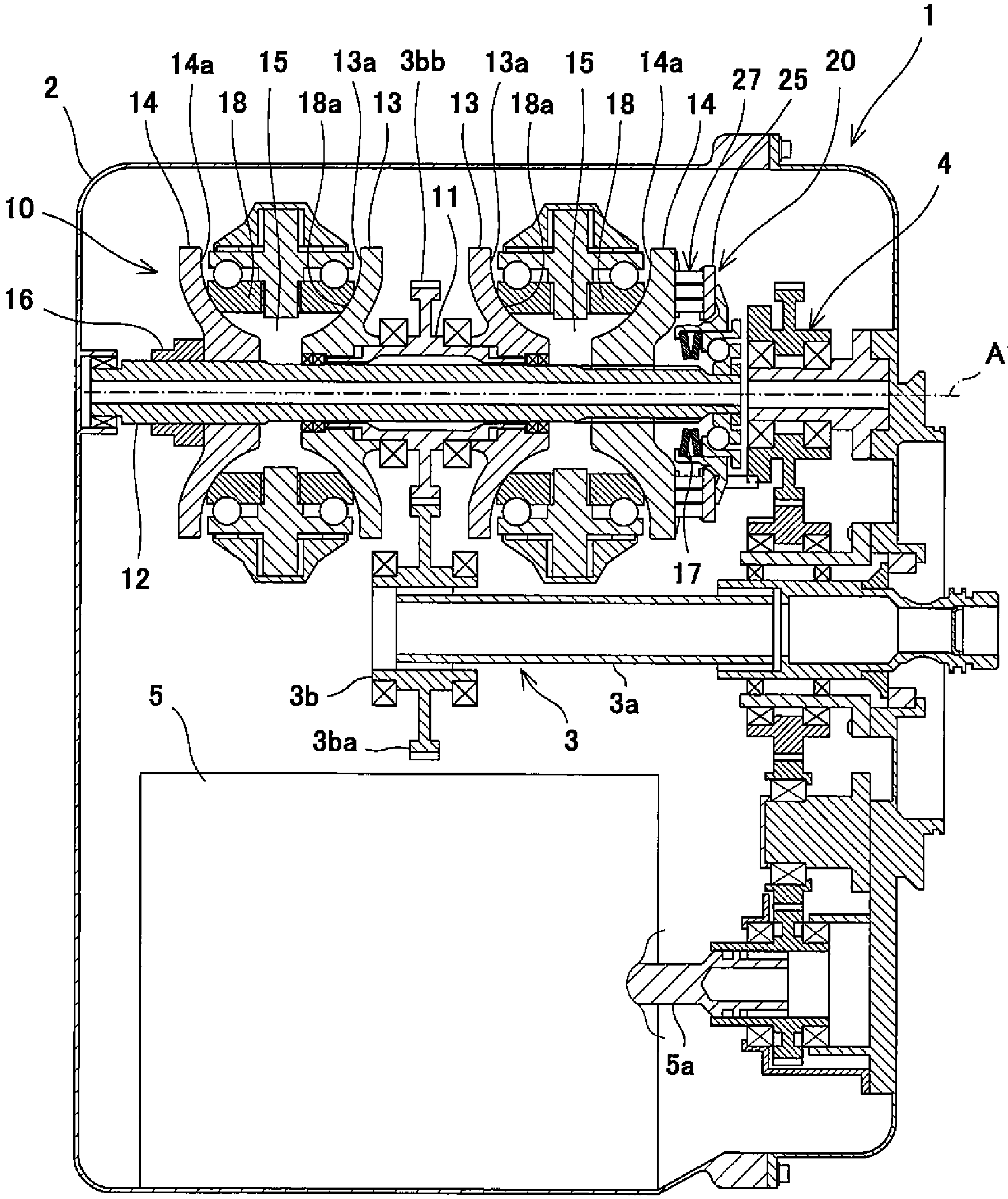
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Fig.1

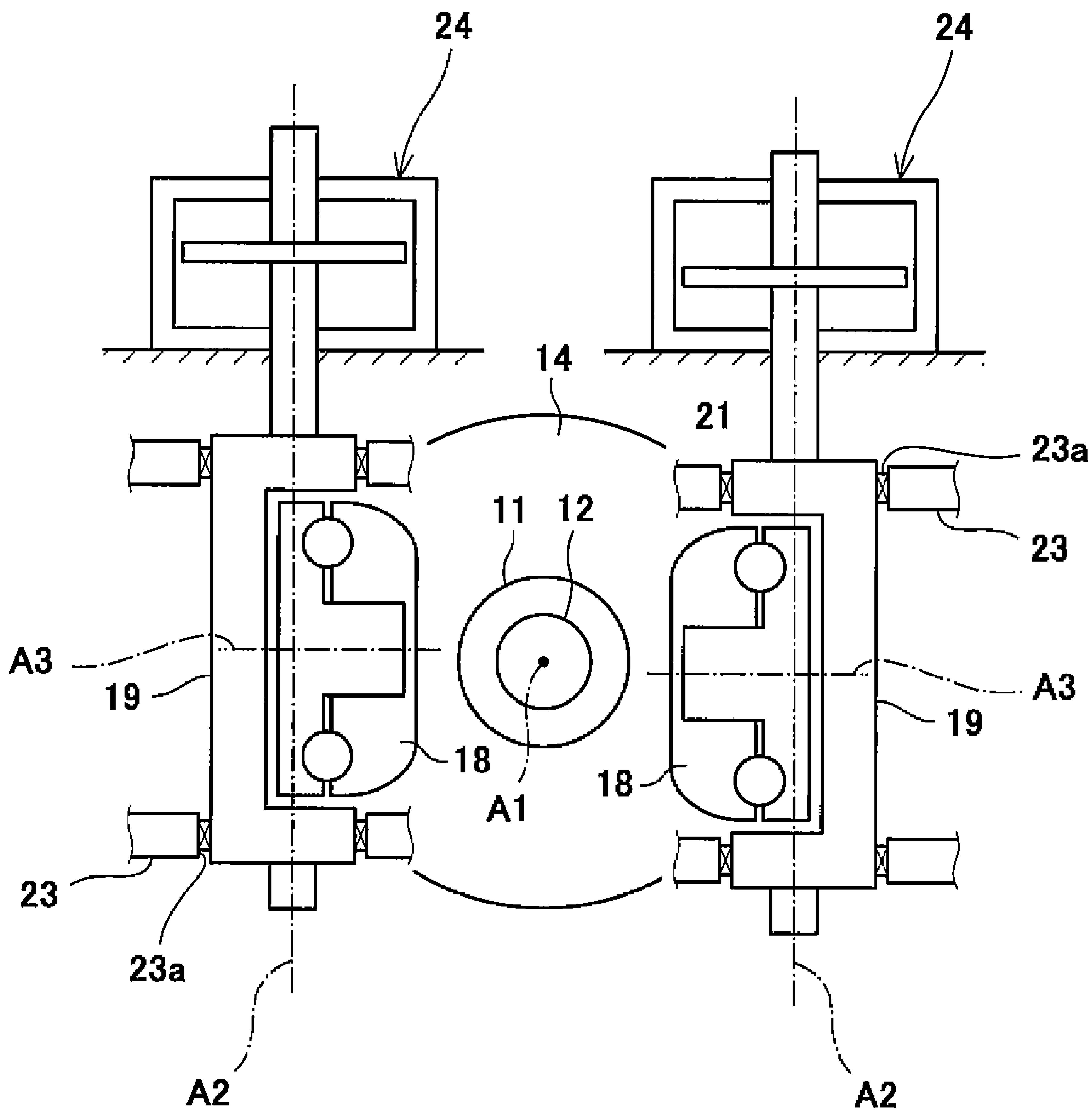
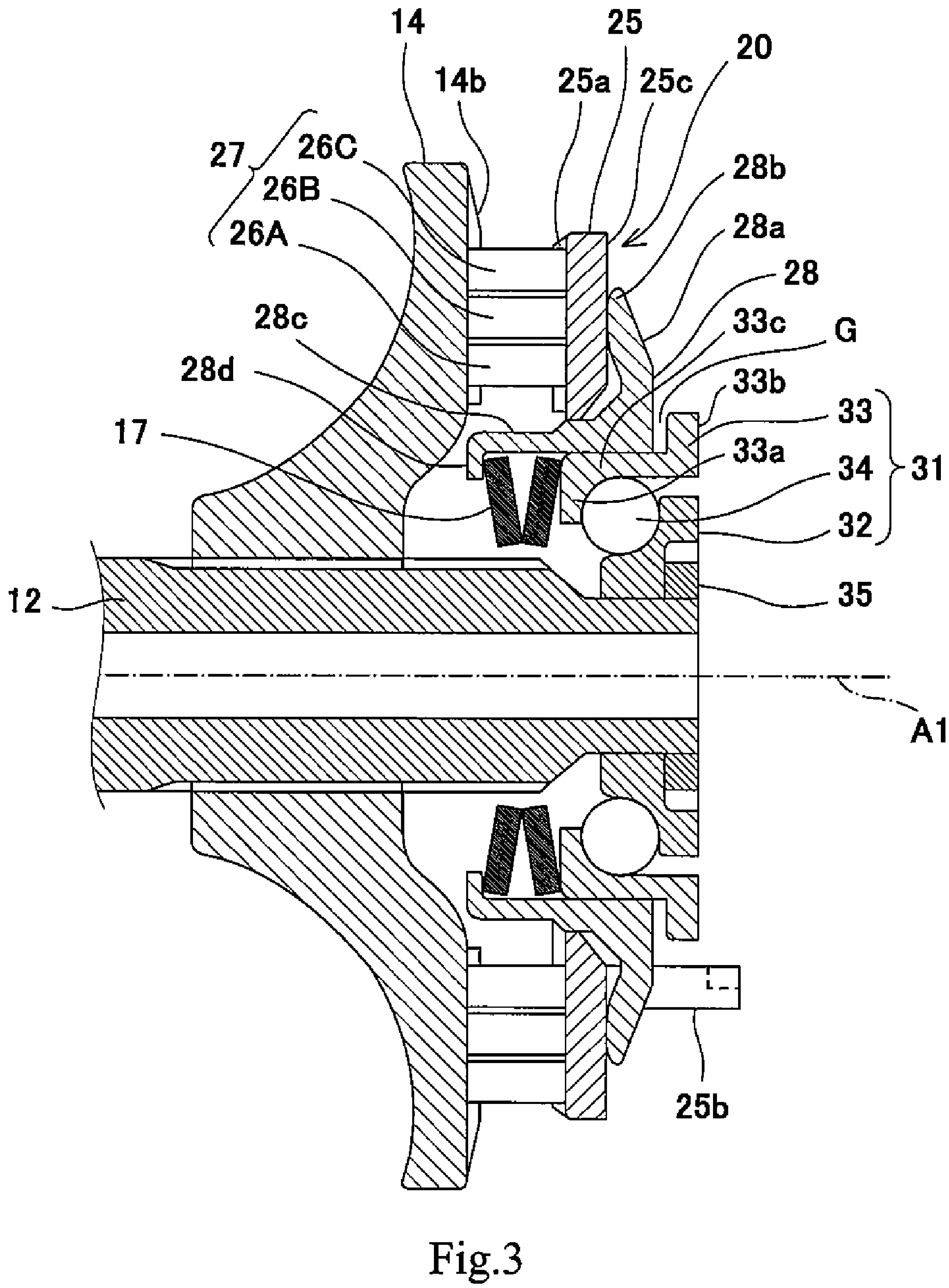


Fig.2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33
17
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34
31
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12
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A1
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Fig.3

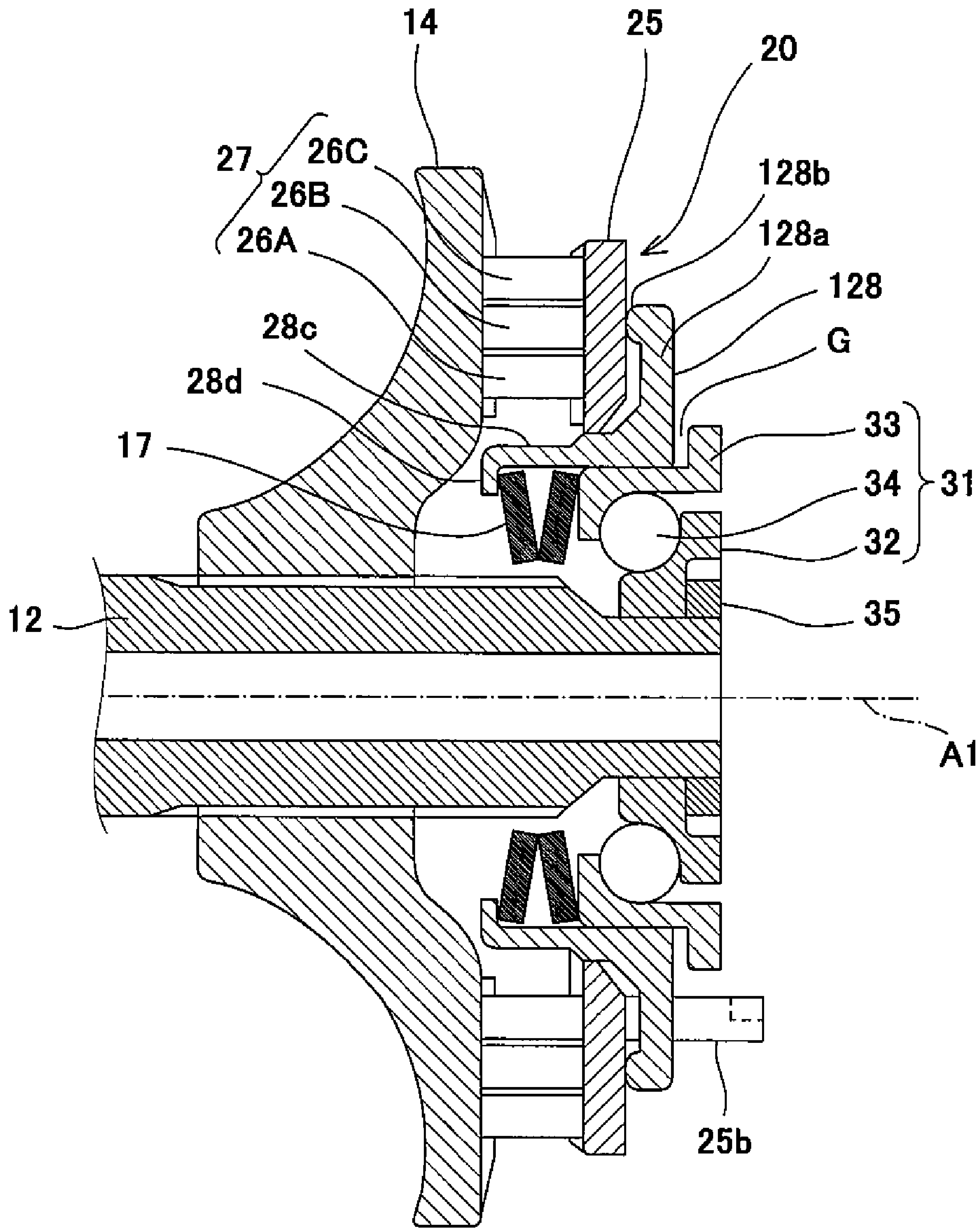
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Fig.4

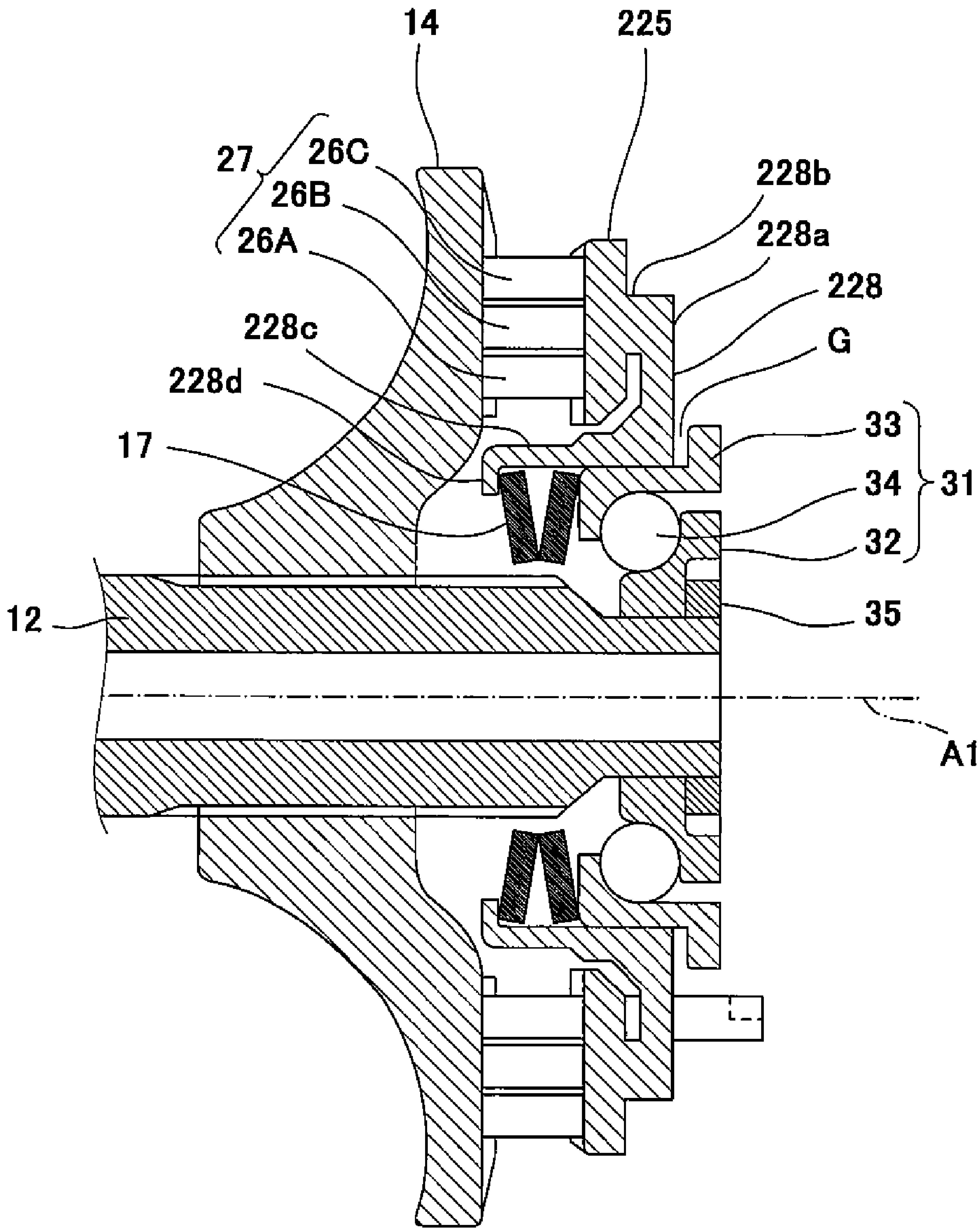
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Fig.5

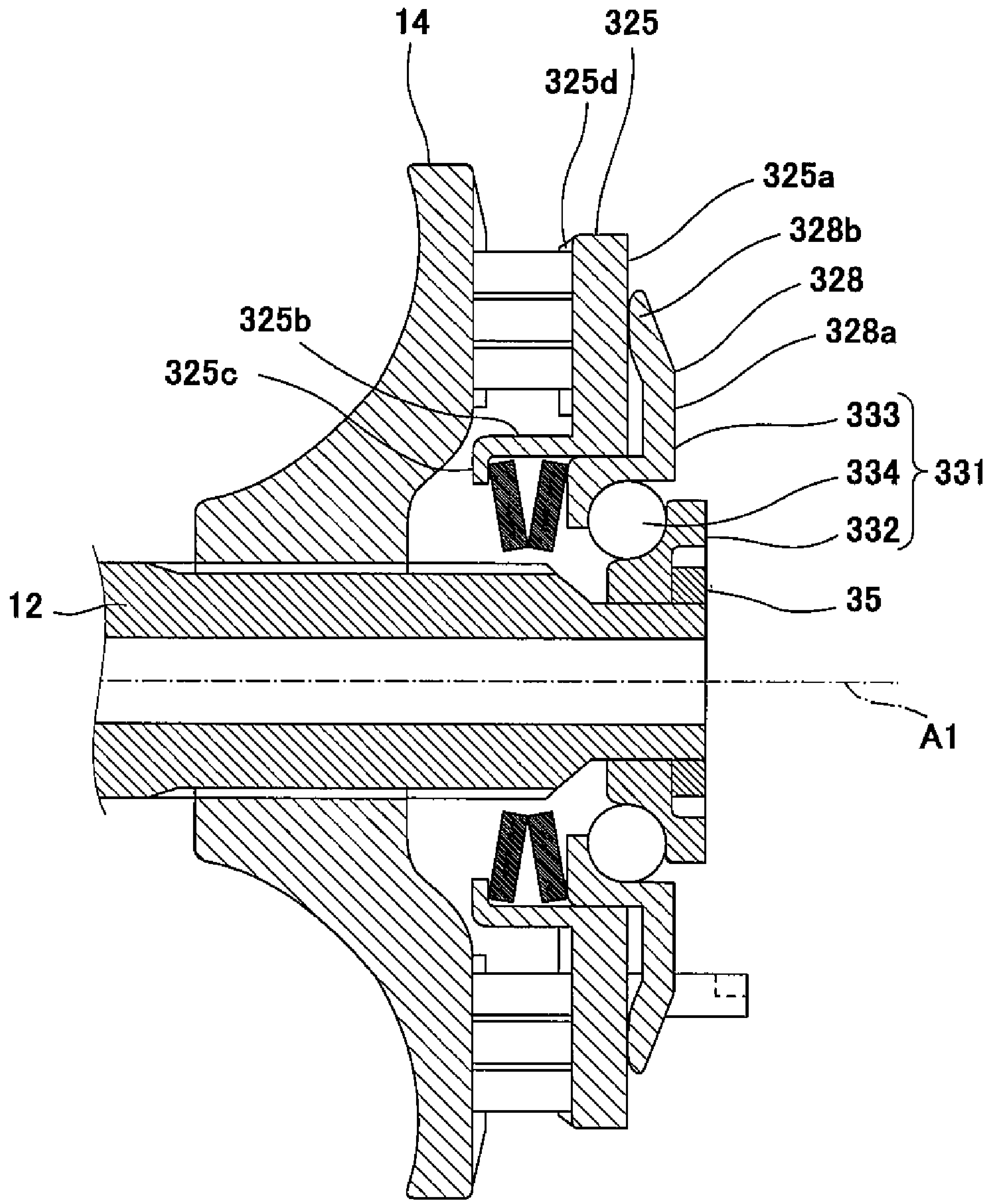
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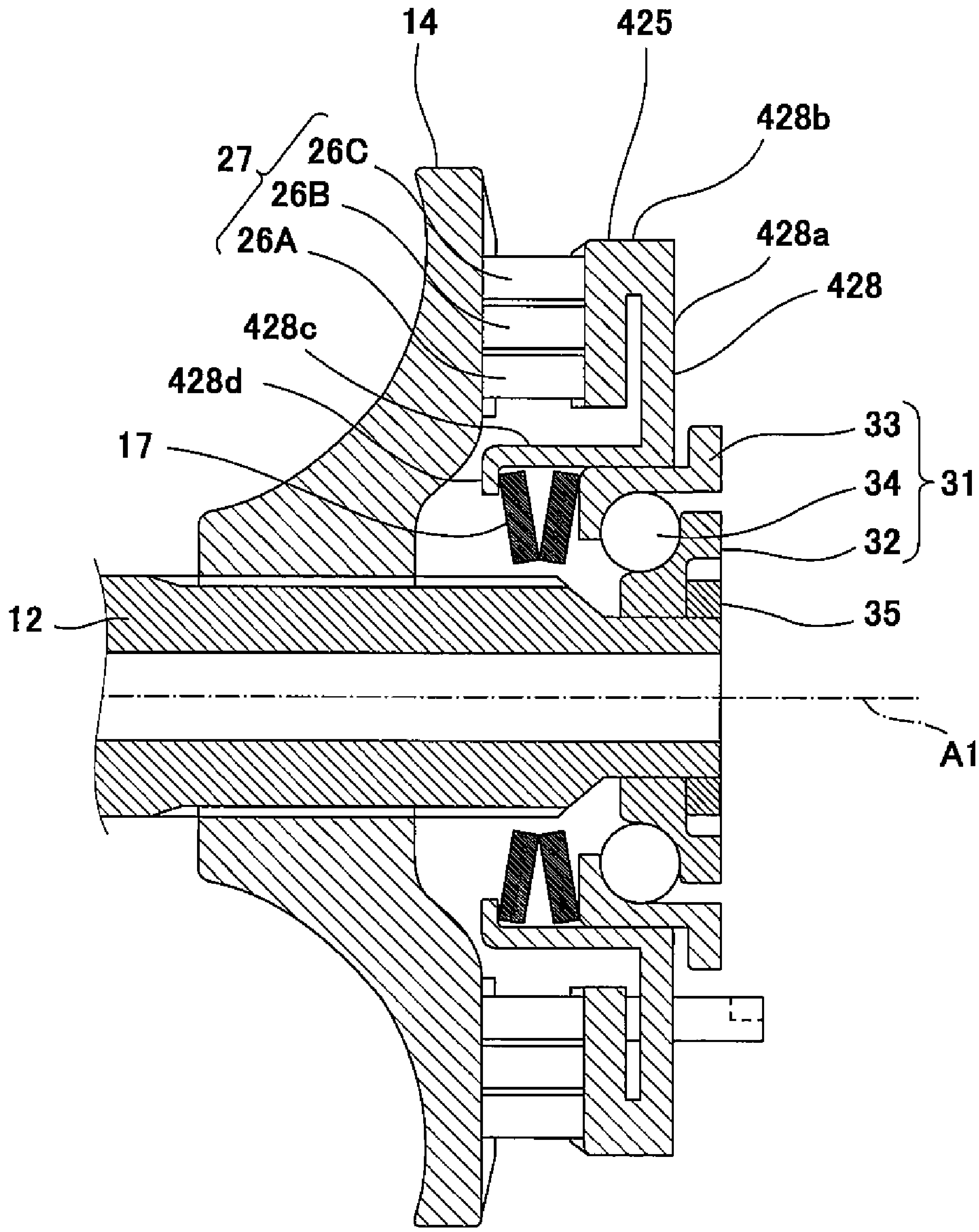
Fig.6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425
428b
27
26C
26B
26A
428a
428
428c
428d
33
17
34
31
32
12
35
A1

Fig.7

TOROIDAL CONTINUOUSLY VARIABLE TRANSMISSION

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a National Stage of International Application No. PCT/JP2017/038241 filed Oct. 24, 2017, claiming priority based on Japanese Patent Application No. 2016-210206 filed Oct. 27, 2016.

TECHNICAL FIELD

The present invention relates to a toroidal continuously variable transmission (toroidal CVT).

BACKGROUND ART

In a toroidal continuously variable transmission (toroidal CVT), power rollers are disposed between an input disc and an output disc, and a transmission ratio (transmission gear ratio) is continuously changed by tilting the power rollers. A toroidal CVT disclosed in Patent Literature 1 is provided with a pressing device of a loading cam type, including a cam plate which is rotatable around a common axis around which the discs are rotatable, and a roller group comprised of a plurality of rollers sandwiched between the disc and the cam plate and arranged in a radial direction. In the pressing device of the loading cam type, with an increase in transmitted torque, the disc is pressed (pushed) away from the cam plate by a cam action. Thus, the input disc and the output disc are biased to become close to each other. In this way, the power rollers are sandwiched with a sufficient contact pressure.

In a case where the cam plate is deflected and warped back by a reaction force from the roller, while high torque is generated, the cam plate is concentratively pressed (pushed) against the roller located radially inward. As a result, the life of this roller is reduced. In addition, torque transmission performance is degraded. As a solution to this, in the pressing device disclosed in Patent Literature 1, the cam surface of at least one of the cam plate and the disc is formed to have a taper shape which is inclined (slanted) in a direction away from the rollers, toward a radially inward side. This makes it possible to prevent a situation in which the roller located radially inward bears a more load all the time.

CITATION LIST

Patent Literature

Patent Literature 1: Japanese Laid-Open Patent Application Publication No. 2005-214373

SUMMARY OF INVENTION

Technical Problem

In the configuration disclosed in Patent Literature 1, the roller located radially outward bears a load while low torque is generated, whereas the roller located radially inward bears a load while high torque is generated. For this reason, the contact pressure between the cam plate and the roller group is non-uniform (uneven) in a radial direction. Therefore, there is a room for improvement in extension of the life and the torque transmission performance. Further, it is necessary to precisely manage a taper angle of the cam surface when the discs and the cam plate are manufactured.

In view of the above, an object of the present invention is to provide a toroidal continuously variable transmission (toroidal CVT) including a pressing device of a loading cam type, which can be manufactured easily and has a long life and stable torque transmission performance.

Solution to Problem

According to an aspect of the present invention, a toroidal continuously variable transmission comprises: a first disc and a second disc disposed so that the first disc and the second disc are rotatable around a common rotational axis line, the first disc and the second disc facing each other; a power roller which is tiltably disposed between the first disc and the second disc; a pressing device of a loading cam type, the pressing device including a cam plate which is rotatable around the rotational axis line, and a roller unit including at least one roller sandwiched between a cam surface of the second disc and a cam surface of the cam plate; and a cam plate support supporting a back surface of the cam plate, the back surface being opposite to the cam surface of the cam plate, at a radial position conforming to a radial position of at least a portion of the roller unit.

In accordance with this configuration, the cam plate support properly receives a reaction force from the roller unit, and the deflection (flexure) of the cam plate is suppressed. Therefore, a contact pressure generated between the cam plate and the roller unit can be kept uniform in the radial direction and a local abrasion (wear) can be prevented. In addition, it becomes possible to prevent a situation in which a part of the roller unit becomes apart from the cam plate. Since the cam plate support supports the cam plate from the back surface side, a simple configuration can be realized. As a result, it becomes possible to provide a toroidal continuously variable transmission (toroidal CVT) including the pressing device of a loading cam type, which can be manufactured easily and has a long life and stable torque transmission performance.

The cam plate support may be separate from the cam plate, and the cam plate support may be configured to contact the back surface of the cam plate so that the cam plate support can become apart from the back surface of the cam plate.

In accordance with this configuration, the cam plate support is not fixed to the cam plate, and a bending stress is not easily transmitted between the cam plate support and the cam plate. Therefore, it is not necessary to manufacture the cam plate support or the like with a highly stiff structure, or to reinforce the cam plate support or the like. This facilitates reduction of a weight.

The portion of the roller unit may be a center portion of the roller unit.

In accordance with this configuration, a contact pressure generated between the cam plate and the roller unit can be suitably made uniform.

The toroidal continuously variable transmission may further comprise: a preload spring which biases the cam plate toward the roller unit in a direction of the rotational axis line, wherein the cam plate support may be disposed between the cam plate and the preload spring.

In accordance with this configuration, the biasing force applied by the preload spring is not directly transmitted to the cam plate and transmitted to the cam plate via the cam plate support. This basing force is applied to the back surface of the cam plate. Therefore, it becomes possible to suppress the tilting of the cam plate by the biasing force applied by the preload spring. This leads to uniformity of a contact pressure generated between the cam plate and the roller unit.

Advantageous Effects of Invention

In accordance with the present invention, it becomes possible to provide a toroidal continuously variable transmission (toroidal CVT) including a pressing device of a loading cam type, which can be manufactured easily and has a long life and stable torque transmission performance.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a cross-sectional view showing an integrated drive generator (IDG) including a toroidal continuously variable transmission (toroidal CVT) according to Embodiment 1.

FIG. **2** is a cross-sectional view showing the toroidal CVT of FIG. **1**, when viewed from a direction of a rotational axis line.

FIG. **3** is an enlarged view showing major components (constituents) of the toroidal CVT of FIG. **1**.

FIG. **4** is a view showing a toroidal CVT according to Embodiment 2, corresponding to FIG. **3**.

FIG. **5** is a view showing a toroidal CVT according to Embodiment 3, corresponding to FIG. **3**.

FIG. **6** is a view showing a toroidal CVT according to Embodiment 4, corresponding to FIG. **3**.

FIG. **7** is a view showing a toroidal CVT according to Embodiment 5, corresponding to FIG. **3**.

DESCRIPTION OF EMBODIMENTS

Hereinafter, the embodiments of the present invention will be described with reference to the drawings.

Embodiment 1

FIG. **1** is a cross-sectional view showing an integrated drive generator **1** including a toroidal continuously variable transmission (toroidal CVT) **10** according to the embodiment. As shown in FIG. **1**, the integrated drive generator **1** (hereinafter will be referred to as "IDG") is used in an AC power supply of an aircraft, and includes a casing **2** mounted on an engine of the aircraft. In the casing **2**, an input mechanism **3**, the toroidal CVT **10** (hereinafter will be referred to as "transmission"), a driving force transmission mechanism **4**, and an electric power generator **5** are accommodated. Note that the toroidal CVT **10** is not limited to a part of the IDG, and its use is not limited to the aircraft.

The transmission **10** includes a transmission input shaft **11** and a transmission output shaft **12** which are placed coaxially and are relatively rotatable (hereinafter, the axis lines of the shafts **11** and **12** will be referred to as "rotational axis line A1"). The transmission input shaft **11** is connected to an engine rotary shaft (not shown) via the input mechanism **3**. The input mechanism **3** includes a device input shaft **3***a* to which a rotational driving force taken out of the engine rotary shaft is input, and a pair of gears **3***b* which transmit the rotation of the device input shaft **3***a* to the transmission input shaft **11**. The pair of gears **3***b* include a gear **3***ba* which is rotatable together with the device input shaft **3***a*, and a gear **3***bb* which is rotatable together with the transmission input shaft **11**. The transmission output shaft **12** is connected to an electric power generator input shaft **5***a* of the electric power generator **5** via a driving force transmission mechanism **4** (e.g., gear train).

The rotational driving force taken out of the engine rotary shaft is input to the transmission input shaft **11** via the input mechanism **3**. The transmission **10** changes the speed of the rotation of the transmission input shaft **11** and outputs the rotation to the transmission output shaft **12**. The rotational driving force is transmitted from the transmission output shaft **12** to the electric power generator input shaft **5***a* via the driving force transmission mechanism **4**. When the electric power generator input shaft **5***a* is driven to rotate, the electric power generator **5** generates AC power. A transmission ratio (transmission gear ratio) of the transmission **10** is continuously changed so that the rotation speed of the electric power generator input shaft **5***a* is kept at a proper value (value corresponding to a frequency which is suitable for the operations of electric components in the aircraft), irrespective of a change of the rotation speed of the engine rotary shaft.

The transmission **10** is, for example, a half toroidal and double cavity CVT. The transmission **10** includes two sets of input disc **13** (first disc) and output disc **14** (second disc). The input discs **13** are fitted to the transmission input shaft **11** so that the input discs **13** are rotatable together with the transmission input shaft **11**. The output discs **14** are fitted to the transmission output shaft **12** so that the output discs **14** are rotatable together with the transmission output shaft **12**. The two sets of discs **13**, **14** are disposed at locations that are adjacent to each other in the direction of the rotational axis line **A1** so that the discs **13**, **14** are rotatable around the rotational axis line **A1**. The input disc **13** and the output disc **14** are disposed to face each other in the direction of the rotational axis line **A1** of the transmission **10**. The input disc **13** and the output disc **14** have concave contact surfaces **13***a*, **14***a*, respectively, facing each other. The input disc **13** and the output disc **14** form an annular cavity **15** around the rotational axis line **A1** by the contact surfaces **13***a*, **14***a*. Note that the transmission is not limited to a transmission with a double cavity configuration. The transmission may be, for example, a transmission with a single cavity configuration.

The transmission **10** has, for example, a center input configuration. The transmission output shaft **12** is inserted into the transmission input shaft **11** and protrudes from the both sides of the transmission input shaft **11**. The two input discs **13** are disposed back-to-back on the transmission input shaft **11**. The two output discs **14** are disposed outward of the two input discs **13** in the direction of the rotational axis line **A1**. The gear **3***bb* which is rotatable together with the transmission input shaft **11** is provided on the outer peripheral surface of the transmission input shaft **11**. The gear **3***bb* is disposed between the two input discs **13**. Note that the configuration of the transmission is not limited to the center input configuration, and may be, for example, a center output configuration. In the case of the center output configuration, a pressing device **20** and a cam plate support **28** which will be described later may be provided on the input disc **13** side.

The output disc **14** on a first side (one side) is fastened to the transmission output shaft **12** by a fastening member **16**. The output disc **14** on a second side (the other side) is biased toward the input disc **13** by a preload spring **17** (e.g., disc spring). During the rotation, the output disc **14** on the second side is biased toward the input disc **13** by the pressing device **20**. The pressing device **20** is a loading cam type pressing device. The output disc **14** is connected to the driving force transmission mechanism **4** via the pressing device **20** so that the driving force is transmitted from the output disc **14** to the driving force transmission mechanism **4**. The transmission **10** includes a plurality of power rollers **18** disposed within the cavity **15** and a plurality of trunnions **19** (see FIG. **2**) which support the plurality of power rollers **18**, respectively so that the plurality of power rollers **18** are tiltable,

FIG. **2** is a cross-sectional view showing the transmission **10** of FIG. **1**, when viewed from the direction of the rotational axis line A**1**. As shown in FIG. **2**, the trunnions **19** are supported by the casing **2** so that each of the trunnions **19** is tiltable around a tilt motion axis line A**2** and displaceable in the direction of the tilt motion axis line A**2**. The tilt motion axis line A**2** is skew with respect to the rotational axis line A**1**. The power rollers **18** are supported by the trunnions **19**, respectively so that each of the power rollers **18** is rotatable around a rotational axis line A**3** perpendicular to the tilt motion axis line A**2**.

Each of the trunnions **19** is rotatably fitted into through-holes **23***a* of yokes **23** secured to the casing **2**. The trunnions **19** are supported by the casing **2** via the yokes **23** so that each of the trunnions **19** is tiltable around the tilt motion axis line A**2** and displaceable in the direction of the tilt motion axis line A**2**. The trunnions **19** are connected to hydraulic driving mechanisms **24**, respectively. Each of the hydraulic driving mechanisms **24** is configured to reciprocatingly displace the trunnion **19** together with the power roller **18** in the direction of the tilt motion axis line A**2**.

As shown in FIGS. **1** and **2**, when the input discs **13** are driven to rotate, the output discs **14** are driven to rotate via the power rollers **18**, and the transmission output shaft **12** is driven to rotate. When the trunnions **19** and the power rollers **18** are displaced in the direction of the tilt motion axis lines A**2**, angles (hereinafter will be referred to as "tilt motion angles") of the power rollers **18** around the tilt motion axis lines A**2** are changed, and the transmission ratio (transmission gear ratio) of the transmission **10** is continuously changed based on the tilt motion angles.

The power rollers **18** are sandwiched between a contact surface **13***a* of the input disc **13** and a contact surface **14***a* of the output disc **14** in a state in which each of the power rollers **18** is tiltable around the tilt motion axis line A**2**. The power rollers **18** change the speed of the rotational driving force of the input disc **13** with the transmission ratio corresponding to the tilt motion angles, and transmit the rotational driving force to the output disc **14**. When the rotation torque of the output disc **14** is increased, the pressing device **20** presses (pushes) the output disc **14** so that the output disc **14** approaches the input disc **13**. Thus, a pressing force with which the power rollers **18** are sandwiched between the input disc **13** and the output disc **14** is increased.

FIG. **3** is an enlarged view showing major components (constituents) of the transmission **10** of FIG. **1**. As shown in FIG. **3**, the output disc **14** has a cam surface **14***b* on a side opposite to the input disc **13**. The pressing device **20** is rotatably placed coaxially with the output disc **14**. The pressing device **20** includes a cam plate **25** which is rotatably disposed coaxially with the output disc **14**, the cam plate **25** being an annular plate having a cam surface **25***a* facing the cam surface **14***b* of the output disc **14**, and a roller unit **27** (roller group) comprised of a plurality of (e.g., three) rollers **26**A to **26**C sandwiched between the output disc **14** and a cam plate **25**, the rollers **26**A to **26**C being arranged in a radial direction perpendicular (orthogonal) to the rotational axis line A**1**. The cam plate **25** is externally fitted to a tubular portion **28***c* of the cam plate support **28** which will be described later. The cam plate **25** includes a dog **25***b* protruding outward in the direction of the rotational axis line A**1**. The dog **25***b* is engaged with the driving force transmission mechanism **4** so that the driving force can be transmitted from the dog **25***b* to the driving force transmission mechanism **4**. Note that the engagement between the cam plate **25** and the driving force transmission mechanism **4** is not limited to dog clutch engagement so long as the driving force can be transmitted from the cam plate **25** to the driving force transmission mechanism **4**. For example, the engagement between the cam plate **25** and the driving force transmission mechanism **4** may be spline connection.

The cam surface **14***b* of the output disc **14** and the cam surface **25***a* of the cam plate **25**, facing each other, are formed with smooth concave and convex portions in the circumferential direction. The rollers **26**A to **26**C are sandwiched between the cam surfaces **14***b*, **25***a* in the direction of the rotational axis line A**1** and in the circumferential direction around the rotational axis line A**1**. When rotation torque of the output disc **14** and the cam plate **25** is increased, the output disc **14** is pressed (pushed) in a direction away from the cam plate **25** by a cam action.

The cam plate **25** is supported by the cam plate support **28** which is separate from the cam plate **25**. Alternatively, the cam plate **25** and the cam plate support **28** may be integrated instead of being separate from each other. The cam plate and the cam plate support may be formed of the same material or different materials. In a case where the cam plate and the cam plate support are formed of different materials, the cam plate support **28** is formed of a material with a specific weight (gravity) lower than that of the cam plate **25**. The cam plate support **28** supports a back surface **25***c* of the cam plate **25**, the back surface **25***c* being opposite to the cam surface **25***a*, at a radial position conforming to that of a portion of the roller unit **27**. The cam plate support **28** is disposed between the cam plate **25** and a preload spring **17**. The preload spring **17** and a thrust bearing **31** are disposed between the cam plate support **28** and the transmission output shaft **12** in the direction of the rotational axis line A**1**. Specifically, the cam plate support **28** is provided so that a movement with a predetermined amount or more to an outward side in the direction of the rotational axis line A**1** with respect to the transmission output shaft **12** which is a driving force transmission shaft is restricted. The "thrust bearing" is defined as all kinds of bearings which receive a thrust force. The thrust bearing may be a bearing which receives a radial force as well as the thrust force. For example, the thrust bearing may be a roller bearing.

The cam plate support **28** includes an arm portion **28***a* extending in the radial direction along the back surface **25***c* of the cam plate **25** in a state in which the arm portion **28***a* is apart from the back surface **25***c* in the direction of the rotational axis line A**1**, a contact portion **28***b* provided at a radially outer portion of the arm portion **28***a*, the contact portion **28***b* being configured to contact the back surface **25***c* of the cam plate **25** so that the contact portion **28***b* can become apart from the back surface **25***c*, the tubular portion **28***c* extending along the rotational axis line A**1** from the radially inner end portion of the arm portion **28***a* toward the output disc **14**, and a flange portion **28***d* protruding radially inward from the tubular portion **28***c*. In the present embodiment, the flange portion **28***d* is provided at an end portion of the tubular portion **28***c*, the end portion being closer to the output disc **14**. However, the flange portion **28***d* need not be provided at the end portion of the tubular portion **28***c*. The flange portion **28***d* may be provided at the tubular portion **28***cb* at a location that is in the vicinity of a center of the tubular portion **28***cb* in the direction of the rotational axis line A1. Further, the tubular portion **28***c* may be omitted. In this case, the flange portion **28***d* is provided at a radially inner portion of the arm portion **28***a*.

The contact portion **28***b* of the cam plate support **28** is configured to surface-contact the back surface **25***c* of the cam plate **25**, at a radial position conforming to that of the center portion of the roller unit **27**. In the present embodiment, the contact portion **28***b* of the cam plate support **28** is configured to contact the back surface **25***c* of the cam plate **25** at a location where the contact portion **28***b* overlaps with the center roller **26**B of the three rollers **26**A to **26**C arranged in the radial direction, when viewed from the direction of the rotational axis line A**1**. Note that the shape of the contact portion **28***b* of the cam plate support **28** is not limited to the shape of FIG. **3**. For example, the contact portion **28***b* of the cam plate support **28** may have a shape configured to linearly contact the back surface **25***c* of the cam plate **25**. Further, the contact portion **28***b* of the cam plate support **28** may be configured to contact the back surface **25***c* of the cam plate **25** at a radial position different from that of the center portion of the roller unit **27**.

The thrust bearing **31** is externally fitted to the end portion of the transmission output shaft **12**. The thrust bearing **31** is disposed between the transmission output shaft **12** and the preload spring **17**. The thrust bearing **31** includes an inner race **32**, an outer race **33**, and rolling elements **34** disposed between the inner race **32** and the outer race **33**. The inner race **32** is fitted to the transmission output shaft **12** so that movement of the inner race **32** to an outward side in the direction of the rotational axis line A1 with respect to the transmission output shaft **12** is restricted. For example, the inner race **32** is positioned with respect to the rotational axis line A**1** by a nut **35** secured to the end portion of the transmission output shaft **12** and forming a portion of the driving force transmission shaft. Alternatively, the inner race **32** may be integrated with the transmission output shaft **12**. The position of the outer race **33** of the thrust bearing **31** in the direction of the rotational axis line A1 at least partially overlaps with that of the arm portion **28***a* of the cam plate support **28**. In this way, a configuration which is compact in the direction of the rotational axis line A1 is realized.

The preload spring **17** is disposed between the cam plate support **28** and the thrust bearing **31**. The preload spring **17** applies a preload to the output disc **14** via the cam plate support **28** and the pressing device **20**, in the direction of the rotational axis line A1 so that the output disc **14** is pressed (pushed) toward the input disc **13**. More specifically, the preload spring **17** is sandwiched between the flange portion **28***d* of the cam plate support **28** and the outer race **33** of the thrust bearing **31**, and compressed in the direction of the rotational axis line A**1**. The position of the preload spring **17** in the direction of the rotational axis line A1 overlaps with those of the rollers **26**A to **26**C.

The cam plate support **28** is placed to be displaceable in the direction of the rotational axis line A1 with respect to the thrust bearing **31**. A gap G is formed between the cam plate support **28** and the thrust bearing **31**, in the direction of the rotational axis line A**1**. In the present embodiment, the gap G is formed between the arm portion **28***a* of the cam plate support **28** and the outer race **33** of the thrust bearing **31**, in the direction of the rotational axis line A1. The outer race **33** includes a spring contact portion **33***a* which contacts the preload spring **17**, and a stopper portion **33***b* facing the arm portion **28***a* of the cam plate support **28** in the direction of the rotational axis line A**1** with the gap G between them. The spring contact portion **33***a* is internally fitted to the tubular portion **28***c* of the cam plate support **28**. The stopper portion **33***b* protrudes radially outward from the outer portion of the spring contact portion **33***a* in the direction of the rotational axis line A**1**.

In the present embodiment, the outer race **33** includes a ring portion **33***c* supporting the rolling elements **34** from a radially outer side. The spring contact portion **33***a* protrudes radially inward from an end portion of the ring portion **33***c*, the end portion being closer to the preload spring **17**. The stopper portion **33***b* protrudes radially outward from the ring portion **33***c*, at a location that is more distant from the preload spring **17** than the spring contact portion **33***a* in the direction of the rotational axis line A**1**. In the example of FIG. **3**, the stopper portion **33***b* is provided at an end portion of the ring portion **33***c*, the end portion being on a side opposite to the spring contact portion **33***a*. However, the stopper portion **33***b* may not be provided at the end portion of the ring portion **33***c* so long as the gap G is formed between the stopper portion **33***b* and the cam plate **21**.

In a state in which the output disc **14** and the pressing device **20** are not rotating, a dimension of the gap G in the direction of the rotational axis line A**1** is less than a deformation amount of the preload spring **17** in the direction of the rotational axis line A, at an elastic limit. Therefore, when the output disc **14** and the pressing device **20** rotate and the output disc **14** and the cam plate **25** start to be relatively displaced in the direction of the rotational axis line A1 so that the output disc **14** and the cam plate **25** become away from each other, by the cam action of the pressing device **20**, the cam plate support **28** contacts the stopper portion **33***b* and the gap G ceases to exist, in a state in which the preload spring **17** is within an elastic deformation range (before the preload spring **17** is plastically deformed).

When a force in the direction of the rotational axis line A**1** is applied from the roller unit **27** to the cam plate **25** by the cam action of the pressing device **20**, the cam plate **25** receives a drag from the cam plate support **28** supported by the preload spring **17** and the thrust bearing **31**, in the direction of the rotational axis line A**1**. At this time, the contact portion **28***b* of the cam plate support **28** is in contact with the back surface **25***c* of the cam plate **25** at a radial position conforming to that of the center portion of the roller unit **27**. Therefore, it becomes possible to prevent a situation in which an application location at which a force is transmitted from the roller unit **27** to the cam plate **25** and an application location at which the drag is transmitted from the cam plate support **28** to the cam plate **25** are deviated from each other in the radial direction. This makes it possible to prevent a situation in which the outer peripheral portion of the cam plate **25** is deflected and warped back while high torque is generated. Thus, the force applied between the rollers **26**A to **26**C and the cam plate **25** is properly deconcentrated.

In accordance with the above-described configuration, the cam plate support **28** properly receives the reaction force from the rollers **26**A to **26**C, and the deflection (flexure) of the cam plate **25** is suppressed. Therefore, a contact pressure generated between the cam plate **25** and the roller unit **27** can be kept uniform in the radial direction and a local abrasion (wear) can be prevented. In addition, it becomes possible to prevent a situation in which some (one or more) of the rollers **26**A to **26**C become(s) apart from the cam plate **25**. Since the cam plate support **28** supports the cam plate **25** from the back surface **25***c* side, the configuration can be simplified. As a result, it becomes possible to provide the toroidal CVT **10** including the pressing device **20** of a loading cam type, which can be manufactured easily and has a long life and stable torque transmission performance.

The cam plate support **28** is separate from the cam plate **25** and is not secured to the cam plate **25**. In this configuration, a bending stress is not easily transmitted between the cam plate support **28** and the cam plate **25**. Therefore, it is not necessary to manufacture the cam plate support **28** or the like with a highly stiff structure, or to reinforce the cam plate support **28** or the like. This facilitates reduction of a weight. The biasing force applied by the preload spring **17** is not directly transmitted to the cam plate **25** and transmitted to the cam plate **25** via the cam plate support **28**. This basing force is applied to the back surface **25***c* of the cam plate **25**. Therefore, it becomes possible to suppress the tilting of the cam plate **25** by the biasing force applied by the preload spring **17** while the low torque is generated. This leads to uniformity of a contact pressure between the cam plate **25** and the roller unit **27**.

When the rotation torque of the output disc **14** and the pressing device **20** increase and the gap G ceases to exist, the stopper portion **33***b* located closer to the contact portion **28***b* than the preload spring **17** contacts and supports the arm portion **28***a* of the cam plate support **28**. For this reason, a moment applied to (acting on) the arm portion **28***a* can be reduced and the deflection (flexure) of the arm portion **28***a* can be suppressed while the high torque is generated. Therefore, the pressing force **20** can generate a proper pressing force without increasing the thickness of the cam plate support **28**. Because of the presence of the cam plate support **28**, it is not necessary to increase the thickness of the cam plate **25**. Therefore, in a case where the cam plate support **28** is formed of a material with a specific weight (gravity) lower than that of the cam plate **25**, the weight is not increased as a whole. Although in the present embodiment, the roller unit **27** is the roller group comprised of the plurality of rollers **26**A to **26**C arranged in the radial direction, the roller unit **27** may be comprised of a single roller.

Embodiment 2

FIG. **4** is a view showing a toroidal CVT according to Embodiment 2, corresponding to FIG. **3**. As shown in FIG. **4**, Embodiment 2 is different from Embodiment 1 in that a cam plate support **128** is configured to contact the cam plate **25** at its curved surface. The cam plate support **128** includes an arm portion **128***a* extending in the radial direction along the back surface **25***c* of the cam plate **25** in a state in which the arm portion **128***a* is apart from the back surface **25***c* in the direction of the rotational axis line A**1**, and a contact portion **128***b* provided at a radially outer portion of the arm portion **128***a*, the contact portion **128***b* being configured to contact the back surface **25***c* of the cam plate **25** so that the contact portion **128***b* can become apart from the back surface **25***c*.

A surface of the contact portion **128***b*, the surface facing the cam plate **25**, has a circular-arc surface which is convex toward the cam plate **25**, in a cross-sectional view including the rotational axis line A**1** and the rollers **26**A to **26**C. A radial position of the apex of the circular-arc surface of the contact portion **28***b* conforms to a radial position of the center of the roller unit **27**. In accordance with this configuration, a force applied from the contact portion **128***b* to the cam plate **25** can be stabilized, irrespective of the posture of the arm portion **128***a* of the cam plate support **28**. The other constituents are the same as those of Embodiment 1, and will not be described in repetition.

Embodiment 3

FIG. **5** is a view showing a toroidal CVT according to Embodiment 3, corresponding to FIG. **3**. As shown in FIG. **5**, Embodiment 3 is different from Embodiment 1 in that a cam plate support **228** is integrated with a cam plate **225**. The cam plate **225** has the same shape as that of the cam plate **25** of Embodiment 1. The cam plate support **228** includes an arm portion **228***a* extending in the radial direction along the back surface of the cam plate **225** in a state in which the arm portion **228***a* is apart from the back surface of the cam plate **225** in the direction of the rotational axis line A**1**, a coupling portion **228***b* protruding from the radially outer portion of the arm portion **228***a* toward the cam plate **225** and secured to the back surface of the cam plate **225**, a tubular portion **228***c* extending along the rotational axis line A**1** from the radially inner end portion of the arm portion **228***a* toward the output disc **14**, and a flange portion **228***d* protruding radially inward, from an end portion of the tubular portion **228***c*, the end portion being closer to the output disc **14**. The cam plate **225** and the cam plate support **228** are secured to each other by welding or the like. Alternatively, the cam plate **225** and the cam plate support **228** may be formed as a unitary component or fastened to each other by a fastening member. The other constituents are the same as those of Embodiment 1, and will not be described in repetition.

Embodiment 4

FIG. **6** is a view showing a toroidal CVT according to Embodiment 4, corresponding to FIG. **3**. As shown in FIG. **6**, Embodiment 4 is different from Embodiment 1 in that a cam plate support **328** is integrated with an outer race **333** of a thrust bearing **331**. The cam plate **325** includes an annular plate portion **325***a* having a cam surface **325***d*, a tubular portion **325***b* extending along the rotational axis line A**1** from the radially inner end portion of the annular plate portion **325***a* toward the output disc **14**, and a flange portion **325***c* protruding radially inward from an end portion of the tubular portion **325***b*, the end portion being closer to the output disc **14**. The thrust bearing **331** includes an inner race **332**, the outer race **333**, and rolling elements **334** disposed between the inner race **332** and the outer race **333**. The outer race **333** is internally fitted to the tubular portion **325***b* of the cam plate **325**.

The cam plate support **328** includes an arm portion **328***a* extending in the radial direction along the annular plate portion **325***a* of the cam plate **325** in a state in which the arm portion **328***a* is apart from the annular plate portion **325***a* in the direction of the rotational axis line A**1**, and a contact portion **328***b* provided radially outward of the arm portion **328***a*, the contact portion **328***b* being configured to contact the back surface of the annular plate portion **325***a* of the cam plate **325** so that the contact portion **328***b* can become apart from the back surface of the annular plate portion **325***a*. The cam plate support **328** and the outer race **333** are secured to each other by welding or the like. Alternatively, the cam plate support **328** and the outer race **333** may be formed as a unitary component or fastened to each other by a fastening member. The other constituents are the same as those of Embodiment 1, and will not be described in repetition.

Embodiment 5

FIG. **7** is a view showing a toroidal CVT according to Embodiment 5, corresponding to FIG. **3**. As shown in FIG. **7**, Embodiment 5 is different from Embodiment 1 in that a cam plate support **428** is integrated with a cam plate **425**, and the cam plate support **428** supports the cam plate **425** at a radially outer portion of the cam plate **425**. The cam plate **425** has the same shape as that of the cam plate **25** of Embodiment 1.

The cam plate support **428** includes an arm portion **428***a* extending in the radial direction along the back surface of the cam plate **425** in a state in which the arm portion **428***a* is apart from the back surface of the cam plate **425** in the direction of the rotational axis line A**1**, a coupling portion **428***b* protruding from the radially outer portion of the arm portion **428***a* toward the cam plate **425** and secured to the back surface of the cam plate **425**, a tubular portion **428***c* extending along the rotational axis line A**1** from the radially inner end portion of the arm portion **428***a* toward the output disc **14**, and a flange portion **428***d* protruding radially inward, from an end portion of the tubular portion **428***c*, the end portion being closer to the output disc **14**. The coupling portion **428***b* is coupled to the back surface of the cam plate **425** at a location that is radially outward of the center portion of the roller unit **27**.

Specifically, the coupling portion **428***b* is coupled to the back surface **25***c* of the cam plate **25** at a location where the coupling portion **428***b* overlaps with the roller **26***c* located on a radially outward side, of the three rollers **26**A to **26**C arranged in the radial direction, when viewed from the direction of the rotational axis line A**1**. The cam plate **425** and the cam plate support **428** are secured to each other by welding or the like. Alternatively, the cam plate **425** and the cam plate support **428** may be formed as a unitary component or may be fastened to each other by a fastening member. In accordance with this configuration, even in a case where a force in the direction of the rotational axis line A**1** is applied from the roller unit **27** to the cam plate **425** by the cam action of the pressing device **20**, the arm portion **428***a* which is elongated in the radial direction is deflected. This makes it possible to suppress a change in the posture of the cam plate **425**. The other constituents are the same as those of Embodiment 1, and will not be described in repetition.

The present invention is not limited to the above-described embodiments. The configuration may be changed, added or deleted. The embodiments may be combined as desired. For example, a constituent (element) or method of one embodiment may be applied to another embodiment. A constituent of the embodiment may be separated from the other constituents of the embodiment and extracted.

REFERENCE SIGNS LIST

10 toroidal continuously variable transmission (toroidal CVT)
13 input disc (first disc)
14 output disc (second disc)
17 preload spring
18 power roller
20 pressing device
25, **225**, **325**, **425** cam plate
26A to **26**C roller
27 roller unit
28, **128**, **228**, **328**, **428** cam plate support
31, **331** thrust bearing
A**1** rotational axis line

The invention claimed is:

1. A toroidal continuously variable transmission comprising:

a first disc and a second disc disposed so that the first disc and the second disc are rotatable around a common rotational axis line, the first disc and the second disc facing each other;

a power roller which is tiltably disposed between the first disc and the second disc;

a pressing device of a loading cam type, the pressing device including a cam plate which is rotatable around the rotational axis line, and a roller unit including at least one roller sandwiched between a cam surface of the second disc and a cam surface of the cam plate; and

a cam plate support supporting a back surface of the cam plate, the back surface being opposite to the cam surface of the cam plate, at a radial position conforming to a radial position of at least a portion of the roller unit.

2. The toroidal continuously variable transmission according to claim **1**,

wherein the cam plate support is separate from the cam plate, and

wherein the cam plate support is configured to contact the back surface of the cam plate so that the cam plate support can separate from the back surface of the cam plate.

3. The toroidal continuously variable transmission according to claim **1**,

wherein the portion of the roller unit is a center portion of the roller unit.

4. The toroidal continuously variable transmission according to claim **1**, further comprising:

a preload spring which biases the cam plate toward the roller unit in a direction of the rotational axis line,

wherein the cam plate support is disposed between the cam plate and the preload spring.

5. The toroidal continuously variable transmission according to claim **2**, further comprising:

a preload spring which biases the cam plate toward the roller unit in a direction of the rotational axis line,

wherein the cam plate support is disposed between the cam plate and the preload spring.

6. The toroidal continuously variable transmission according to claim **3**, further comprising:

a preload spring which biases the cam plate toward the roller unit in a direction of the rotational axis line,

wherein the cam plate support is disposed between the cam plate and the preload spring.

7. The toroidal continuously variable transmission according to claim **2**,

wherein the portion of the roller unit is a center portion of the roller unit.

8. The toroidal continuously variable transmission according to claim **4**,

wherein the cam plate support includes:

an arm portion extending in the radial direction along the back surface of the cam plate in a state in which the arm portion is apart from the back surface, and

a contact portion or a coupling portion provided at a radially outer portion of the arm portion and supports the back surface of the cam plate at the radial position conforming to the radial position of the portion of the roller unit.

9. The toroidal continuously variable transmission according to claim **5**,

wherein the cam plate support includes:

an arm portion extending in the radial direction along the back surface of the cam plate in a state in which the arm portion is apart from the back surface, and

a contact portion or a coupling portion provided at a radially outer portion of the arm portion and supports the back surface of the cam plate at the radial position conforming to the radial position of the portion of the roller unit.

10. The toroidal continuously variable transmission according to claim **6**,

wherein the cam plate support includes:

an arm portion extending in the radial direction along the back surface of the cam plate in a state in which the arm portion is apart from the back surface, and

a contact portion or a coupling portion provided at a radially outer portion of the arm portion and supports the back surface of the cam plate at the radial position conforming to the radial position of the portion of the roller unit.

11. The toroidal continuously variable transmission according to claim **1**,

wherein a position of the preload spring in the direction of the rotational axis line overlaps with those of the roller unit.

12. The toroidal continuously variable transmission according to claim **1**,

wherein the cam plate support is integrated with the cam plate.

13. The toroidal continuously variable transmission according to claim **1**, further comprising:

a driving force transmission shaft that is rotatable together with the second disk,

a thrust bearing disposed between the cam plate support and the driving force transmission shaft in the direction of the rotational axis line,

wherein the cam plate support is integrated with an outer race of the thrust bearing.

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